AGN deep multiwavelength surveys:
the case of the Chandra Deep Field South

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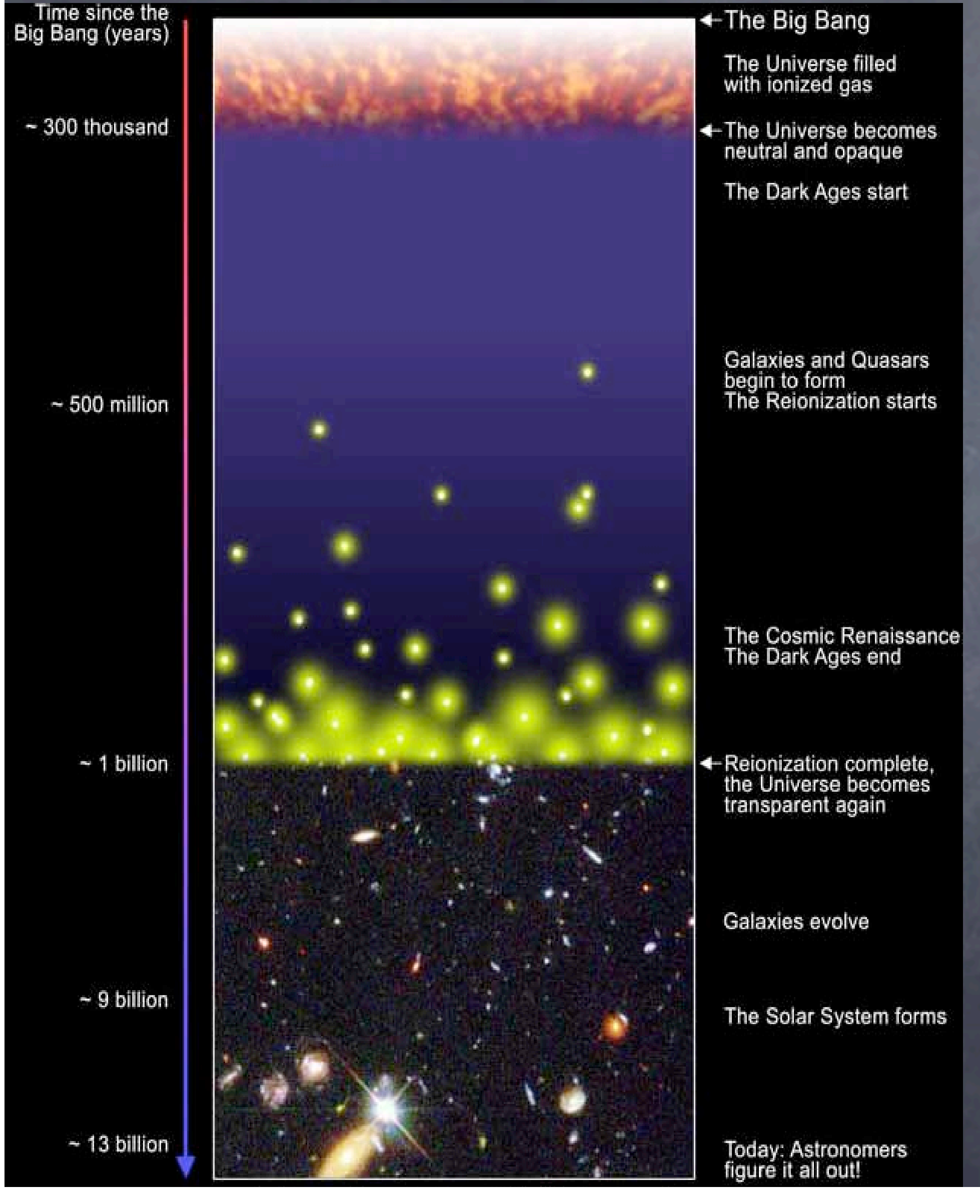
- CDFS 2Msec observation: the X-ray view of IR bright AGN:
  - Spectra of IR sources directly detected in X-rays
  - X-ray “stacking” analysis of the sources not directly detected.

A brief cosmic history

X. Fan, G. Djorgovski



Big bang

Recombination

Dark ages

First stars, SN, GRB,galaxies, AGN

Reionization, light from first objects ionize IGM

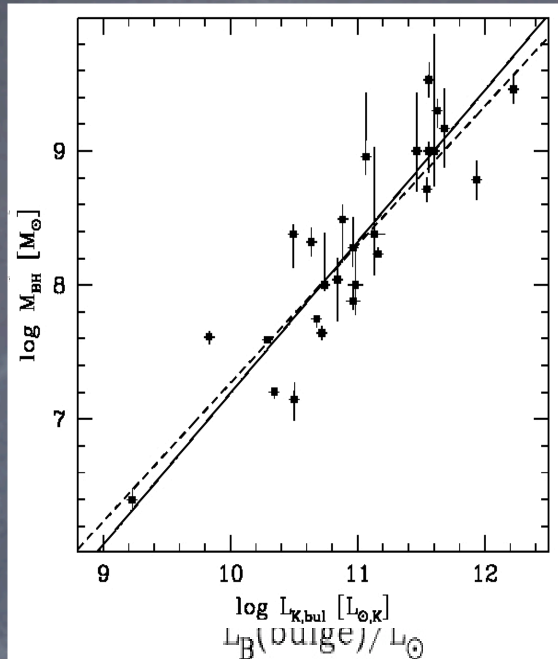
Transparent Universe

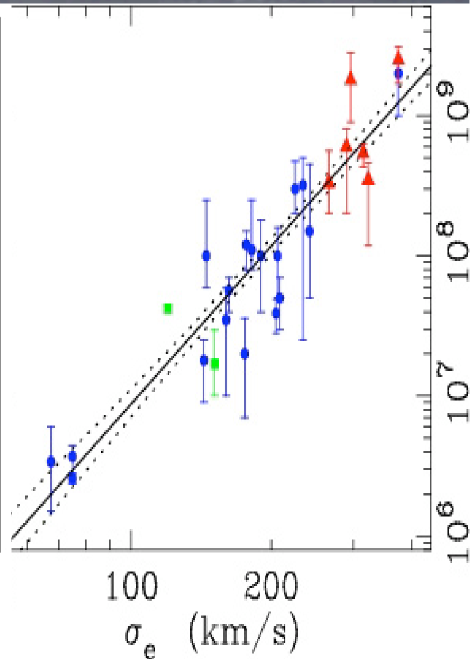
Today

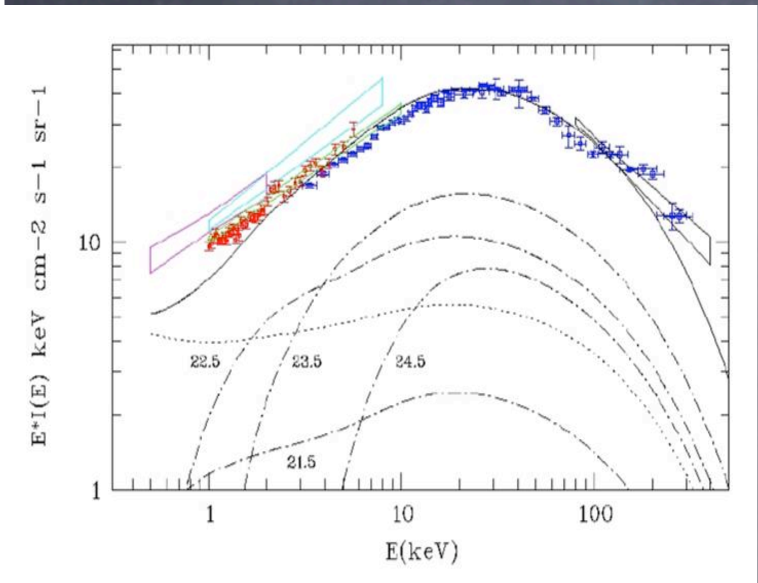
Co-evolution of galaxies and SMBH

Two seminal results:

1. The discovery of SMBH in the most local bulges; **tight correlation** between M_{BH} and bulge properties.
2. The BH mass density obtained integrating the AGN L.-F. and the CXB ~ that obtained from local bulges







⇒ most BH mass accreted during luminous AGN phases!

Most bulges passed a phase of activity:

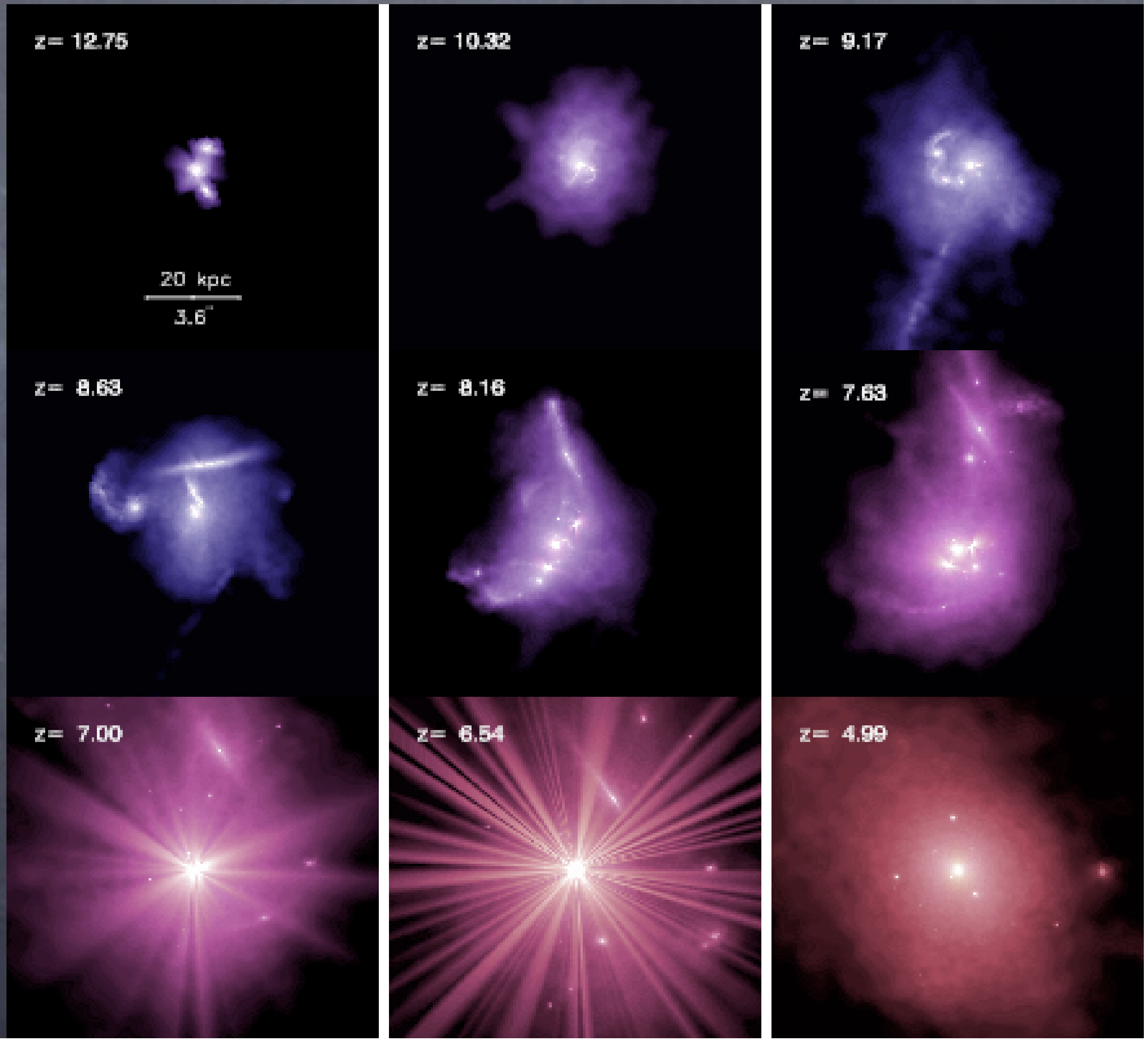
1) Complete SMBH census,
2) full understanding of AGN feedback

are key ingredients to understand galaxy evolution

QuickTime™ e un
decompressore
sono necessari per visualizzare quest'immagine.

AGN and galaxy co-evolution

- Early on
  - Strong galaxy interactions= violent star-bursts
  - Heavily obscured QSOs
- When galaxies coalesce
  - accretion peaks
  - QSO becomes optically visible as AGN winds blow out gas.
- Later times
  - SF & accretion quenched
  - red spheroid, passive evolution



AGN and galaxy co-evolution

- Early on
  - Strong galaxy interactions= violent star-bursts
  - Hea
    QSC
- When
  coales
  - accr
  - QSC
    optic
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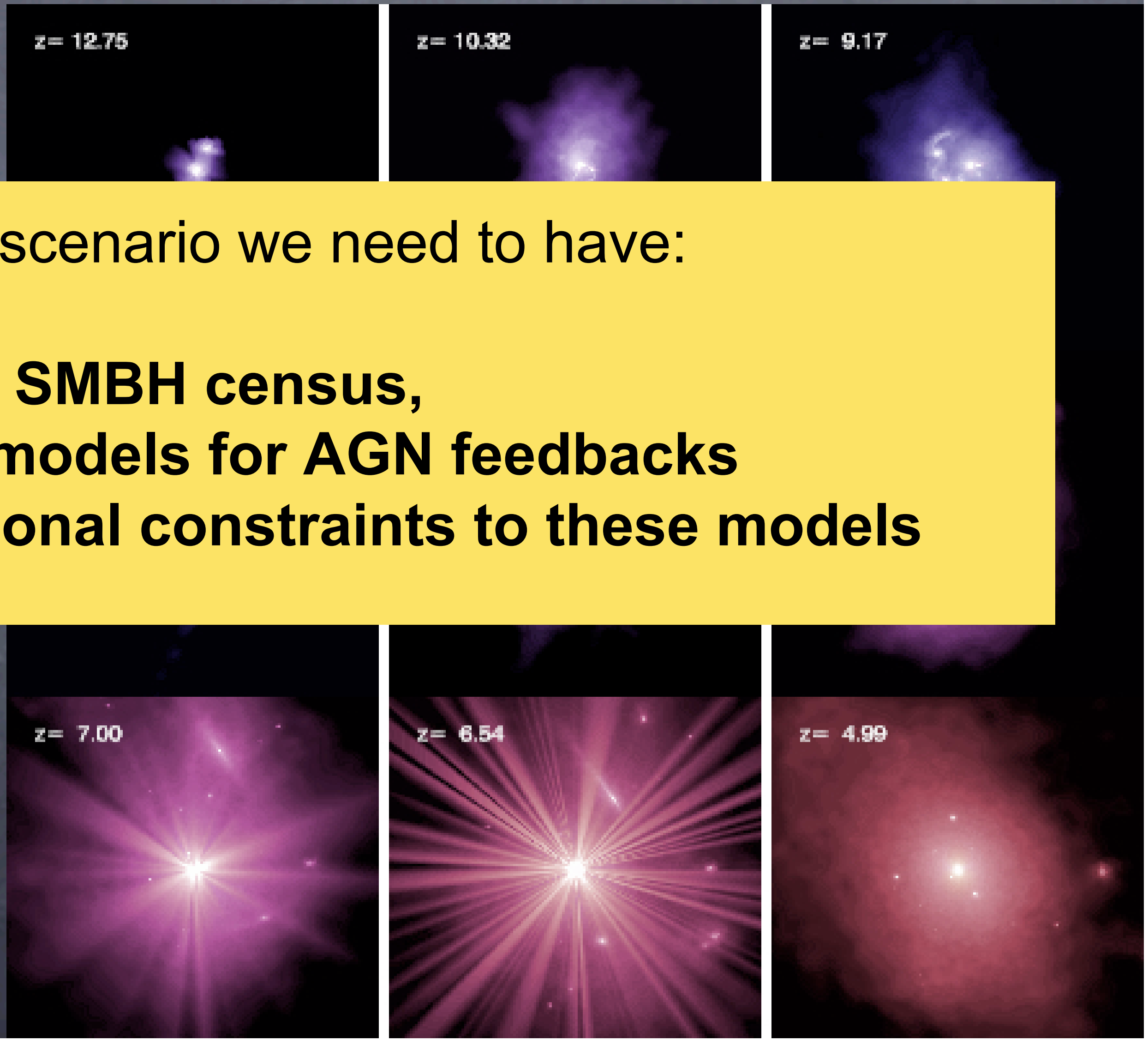
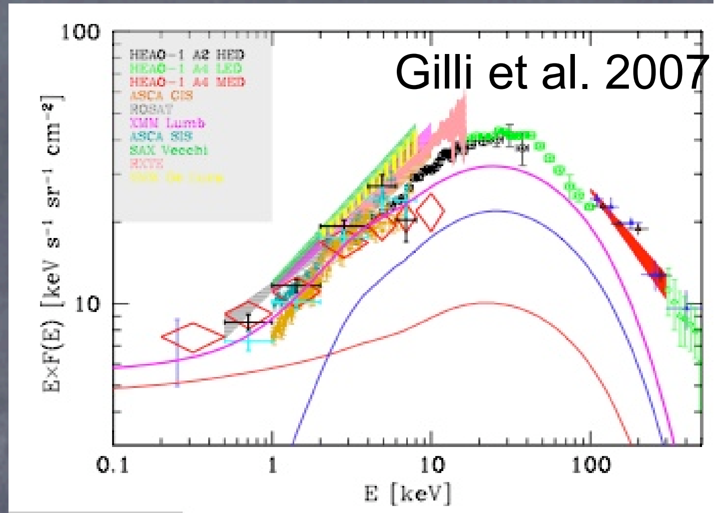


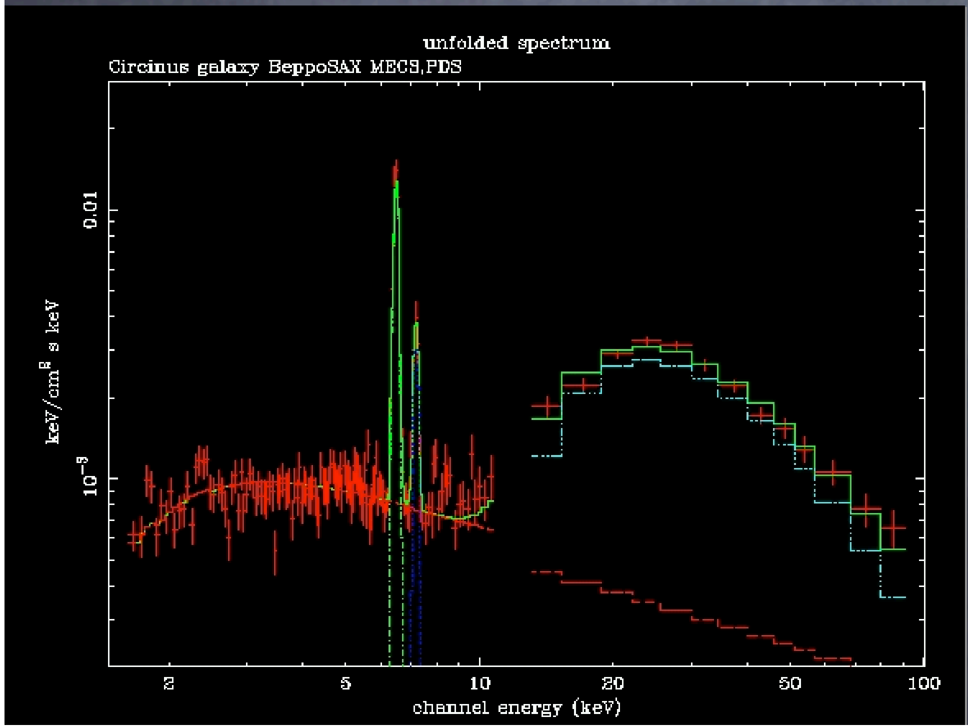
To prove this scenario we need to have:

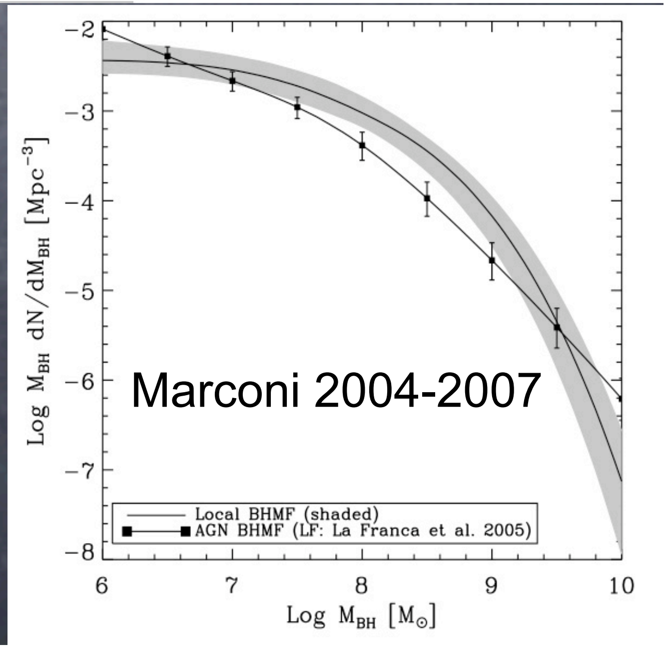
1) **Complete SMBH census,**
2) **Physical models for AGN feedbacks**
3) **Observational constraints to these models**

Hierarchical clustering

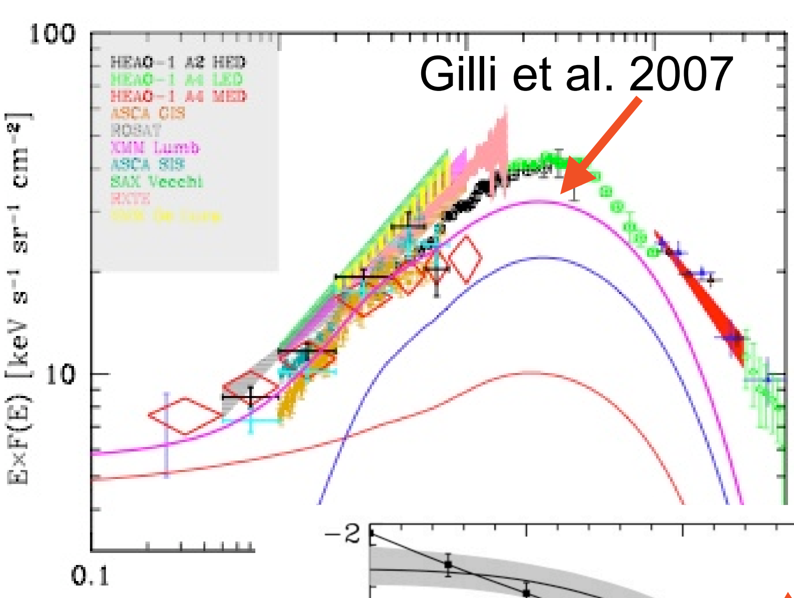
- most massive BH in most massive galaxies, which are in the most massive clusters
- Complete BH census needed.
- Strong evidences for missing BH





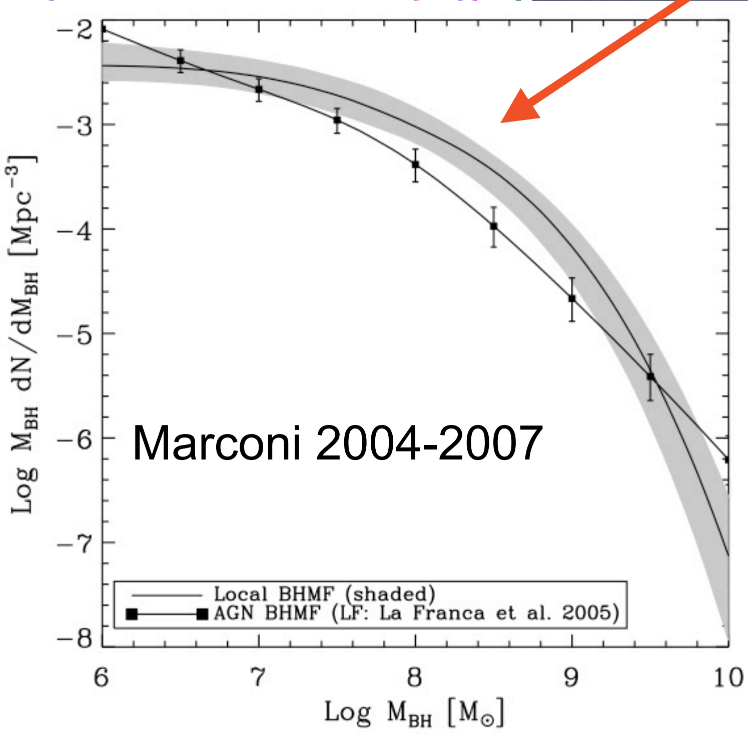


Evidences for missing SMBH

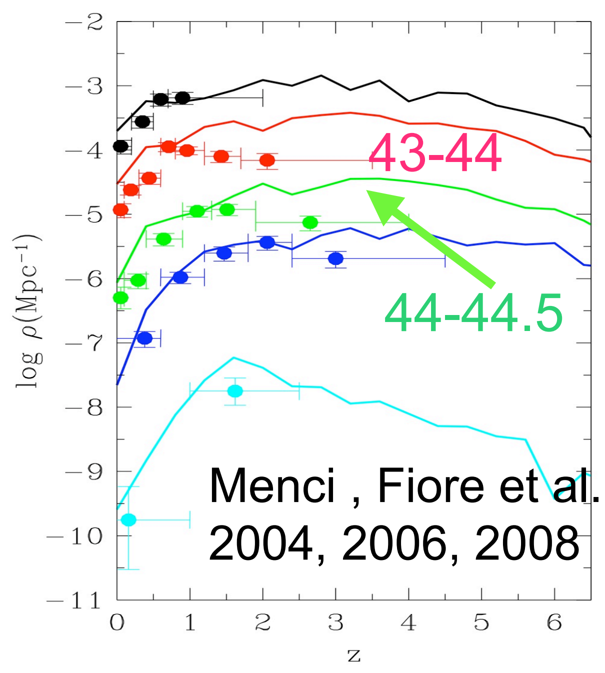


Gilli et al. 2007

While the CXB energy density provides a statistical estimate of SMBH growth, the lack, so far, of focusing instrument above 10 keV (where the CXB energy density peaks), frustrates our effort to obtain a ***comprehensive picture of the SMBH evolutionary properties***.



Marconi 2004-2007



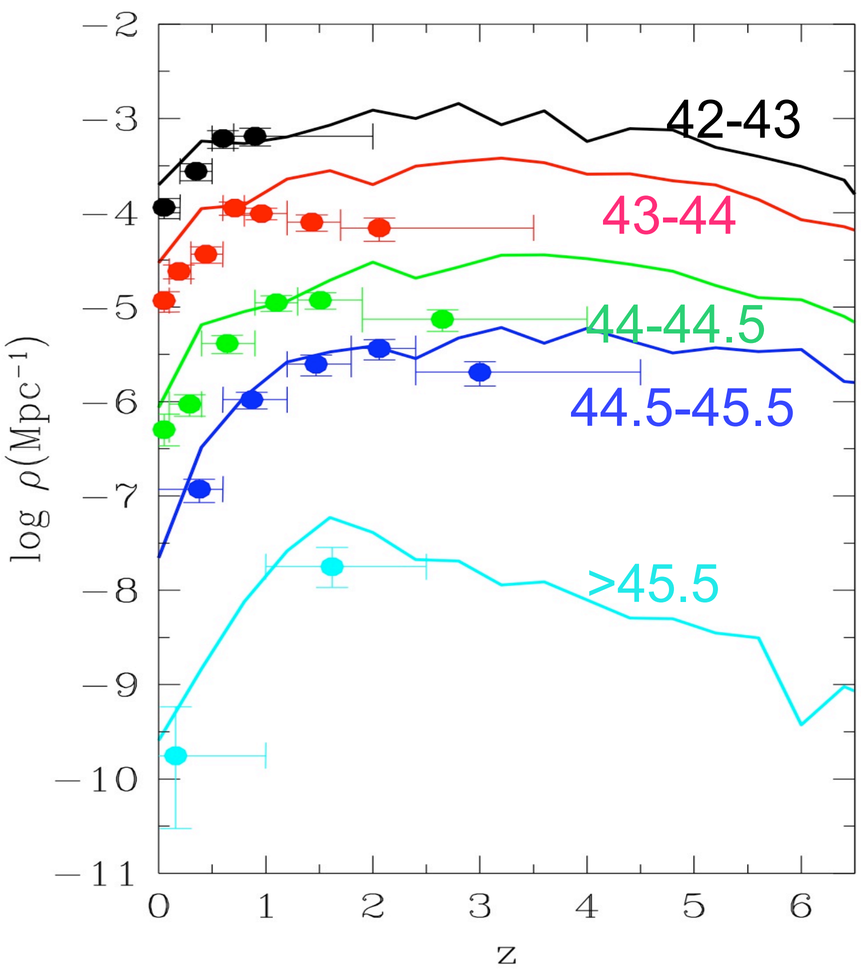
43-44

44-44.5

Menci , Fiore et al.
2004, 2006, 2008

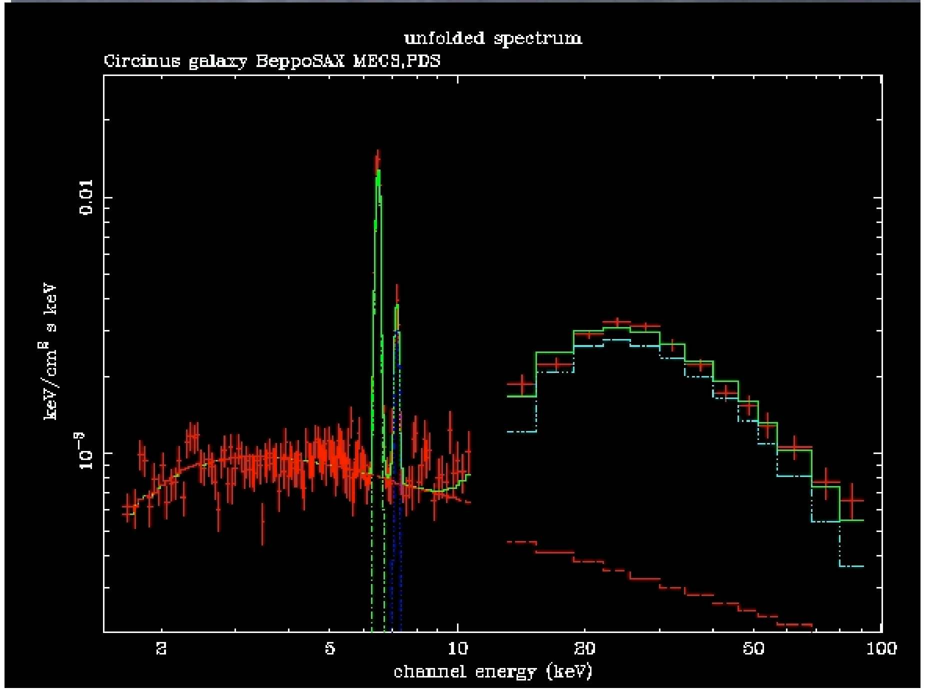
AGN density

La Franca, Fiore et al. 2005
Menci, Fiore et al. 2008



Paucity of Seyfert like sources @ z>1 is real? Or, is it, at least partly, a selection effect?

Are we missing in Chandra and XMM surveys highly obscured ($N_H \times 10^{24}$ cm^{-2}) AGN? Which are common in the local Universe…



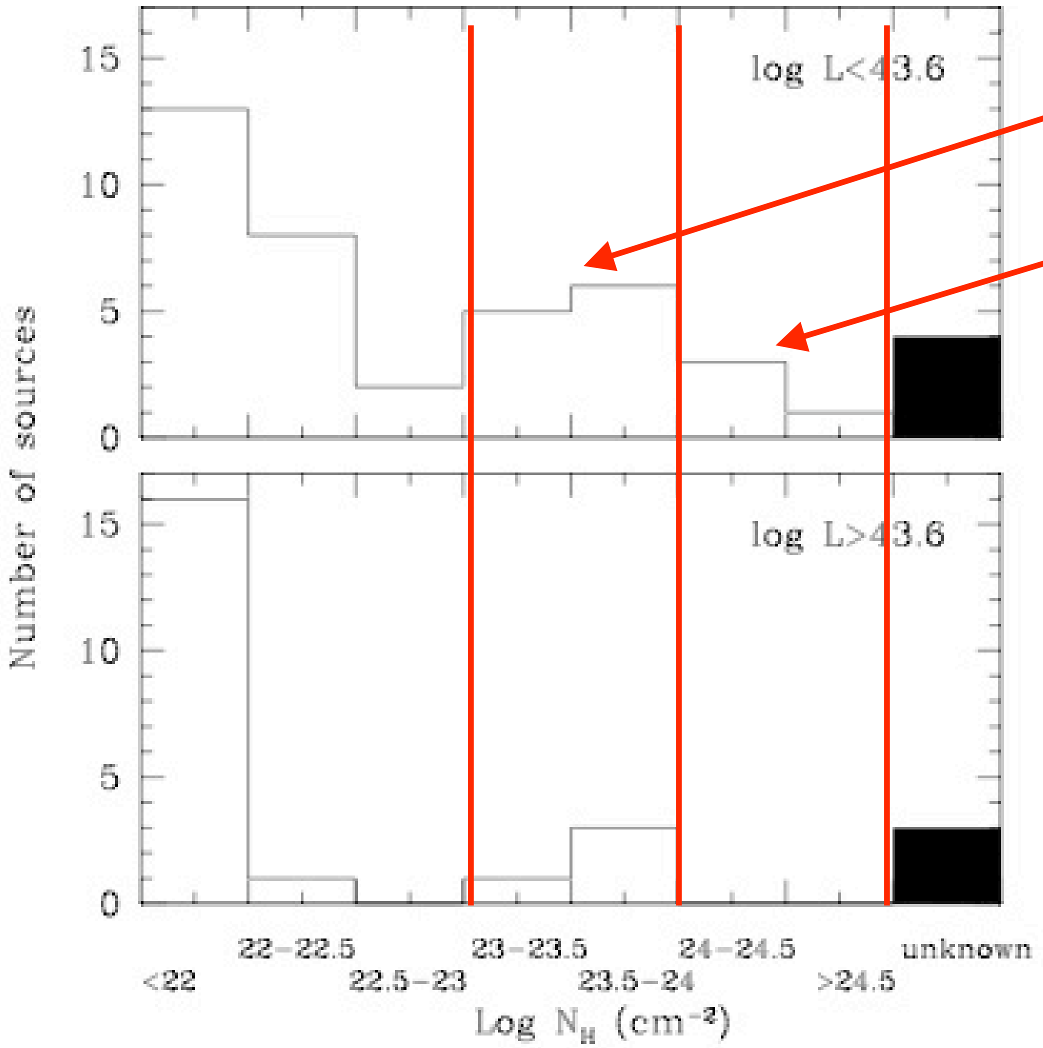


Fig. 2. Observed X-ray absorption distribution of the low-luminosity AGN (top panel), and high-luminosity AGN (bottom panel). The shaded part of each diagram shows the number of AGN with unknown N_H.

Highly obscured

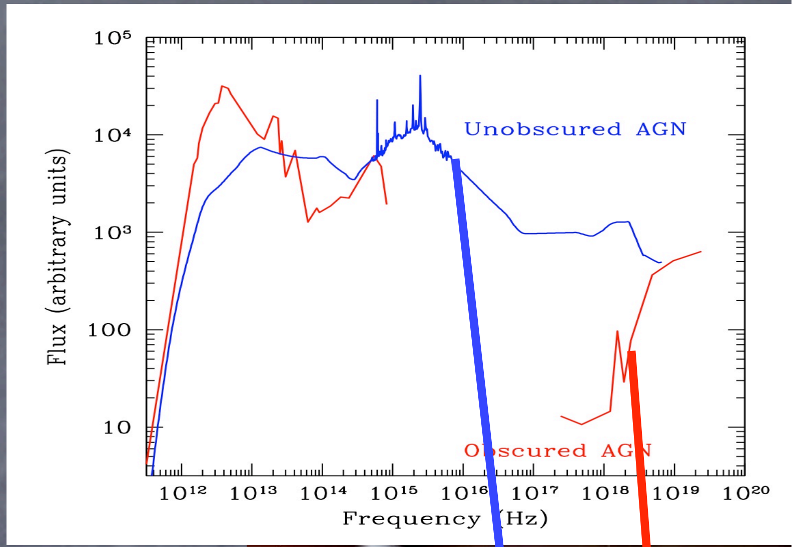
Mildly Compton thick

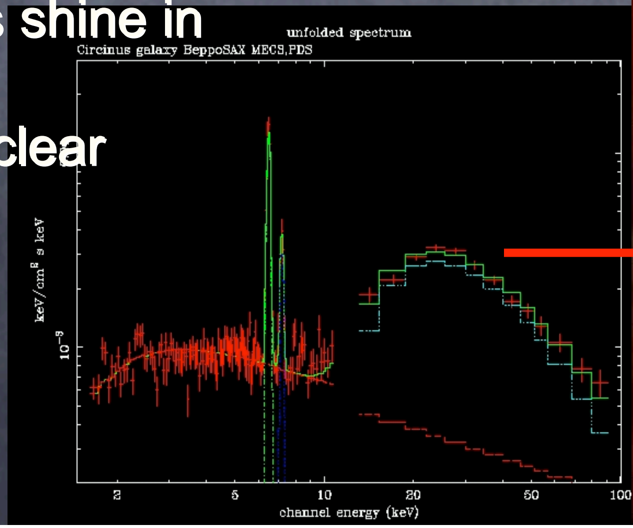
INTEGRAL survey
~ 100 AGN

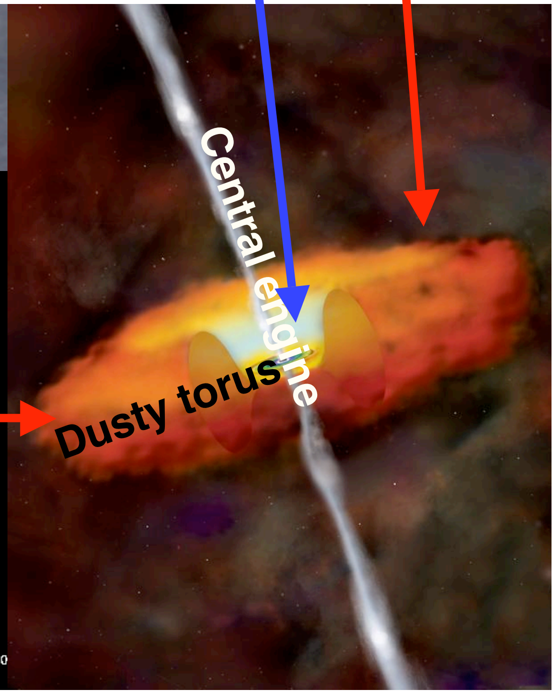
Sazonov et al. 2006

Completing the census of SMBH

- X-ray surveys:
  - very efficient in selecting unobscured and moderately obscured AGN
  - Highly obscured AGN recovered only in ultra-deep exposures
- IR surveys:
  - AGNs highly obscured at optical and X-ray wavelengths shine in the MIR thanks to the reprocessing of the nuclear radiation by dust







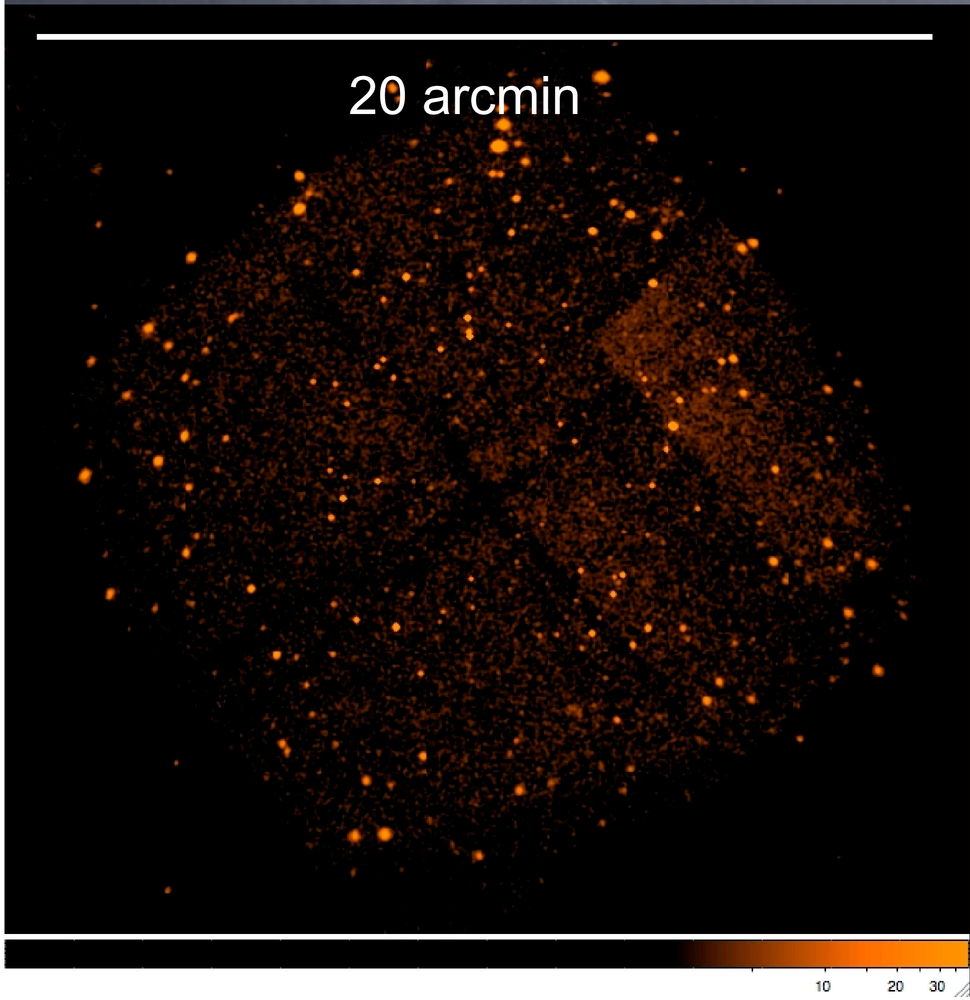
X-ray-MIR surveys

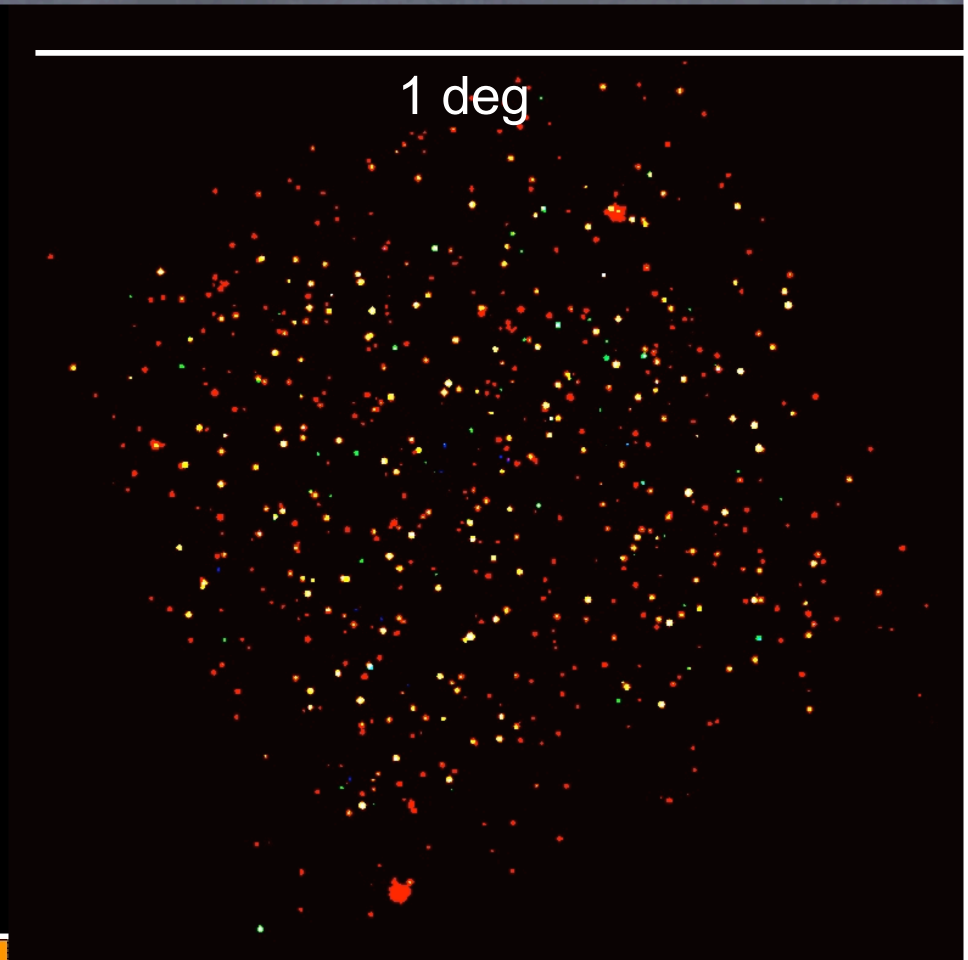
- CDFS-Goods MUSIC catalog (Grazian et al. 2006, Brusa, FF et al. 2008) Area 0.04 deg2
- ~200 X-ray sources, 2-10 keV down to 2×10^{-16} cgs, 0.5-2 keV down to 5×10^{-17} cgs 150 spectroscopic redshifts
- 1100 MIPS sources down to 40 μJy, 3.6μm detection down to 0.08 μJy
- Ultradeep Optical/NIR photometry, R~27.5, K~24
- ELAIS-S1 SWIRE/XMM/Chandra survey (Puccetti, FF et al. 2006, Feruglio,FF et al. 2007, La Franca, FF et al. 2008). Area 0.5 deg2
- 500 XMM sources, 205 2-10 keV down to 3×10^{-15} cgs, >half with spectroscopic redshifts.
- 2600 MIPS sources down to 100 μJy, 3.6μm detection down to 6 μJy
- Relatively deep Optical/NIR photometry, R~25, K~19
- COSMOS XMM/Chandra/Spitzer. Area ~1 deg^2
- ~1700 Chandra sources down to 6×10^{-16} cgs, >half with spectroscopic redshifts.
- 900 MIPS sources down to 500 μJy, 3.6μm detection down to 10 μJy, R~26.5
- In future we will add:
- CDFS-Goods, Chandra 2Msec observation
- CDFN-Goods
- COSMOS deep MIPS survey

Chandra deep and wide fields

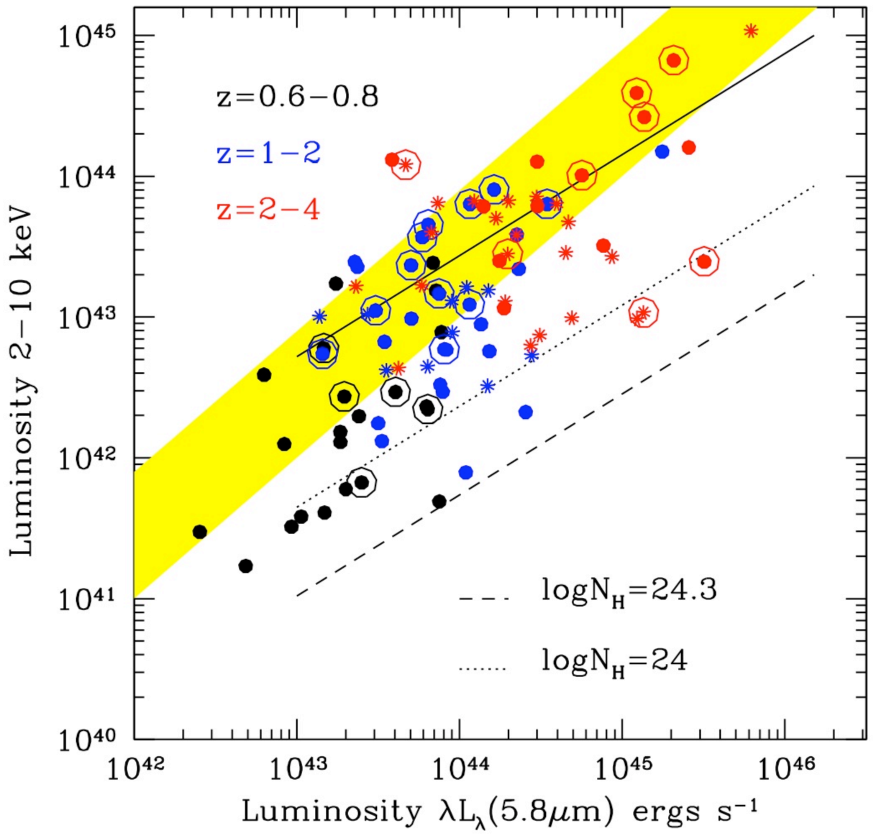
CDFS 2Msec 0.05deg^2
~400 sources

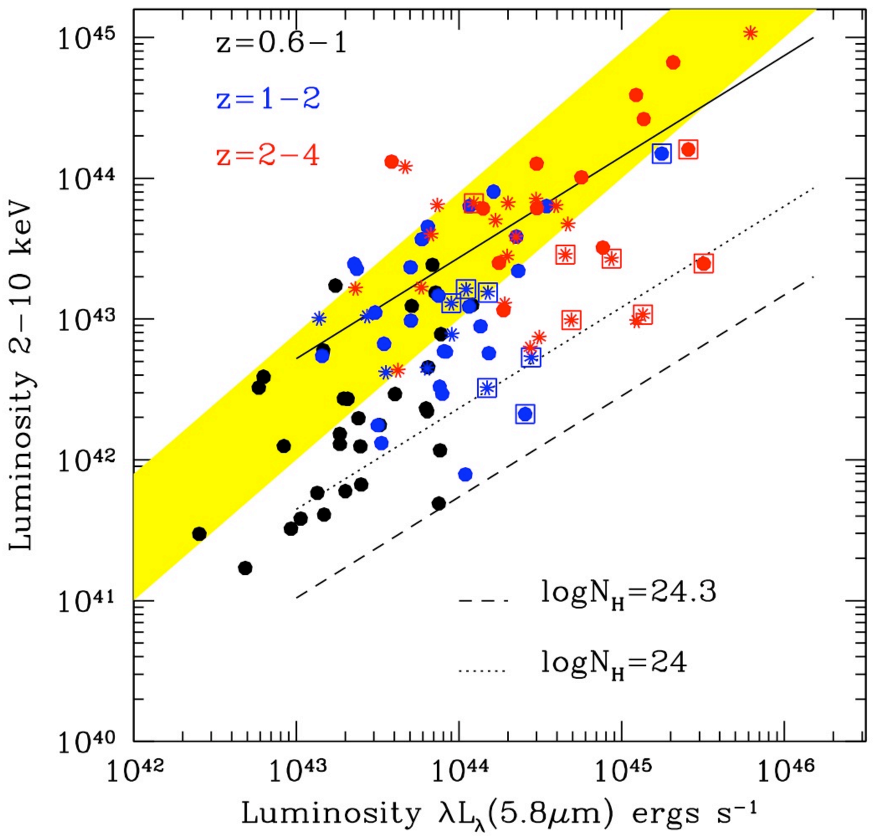
CCOSMOS 200ksec 0.5deg^2 100ksec 0.4deg^2
1.8 Msec ~1800 sources
Elvis et al. 2008





AGN directly detected in X-rays



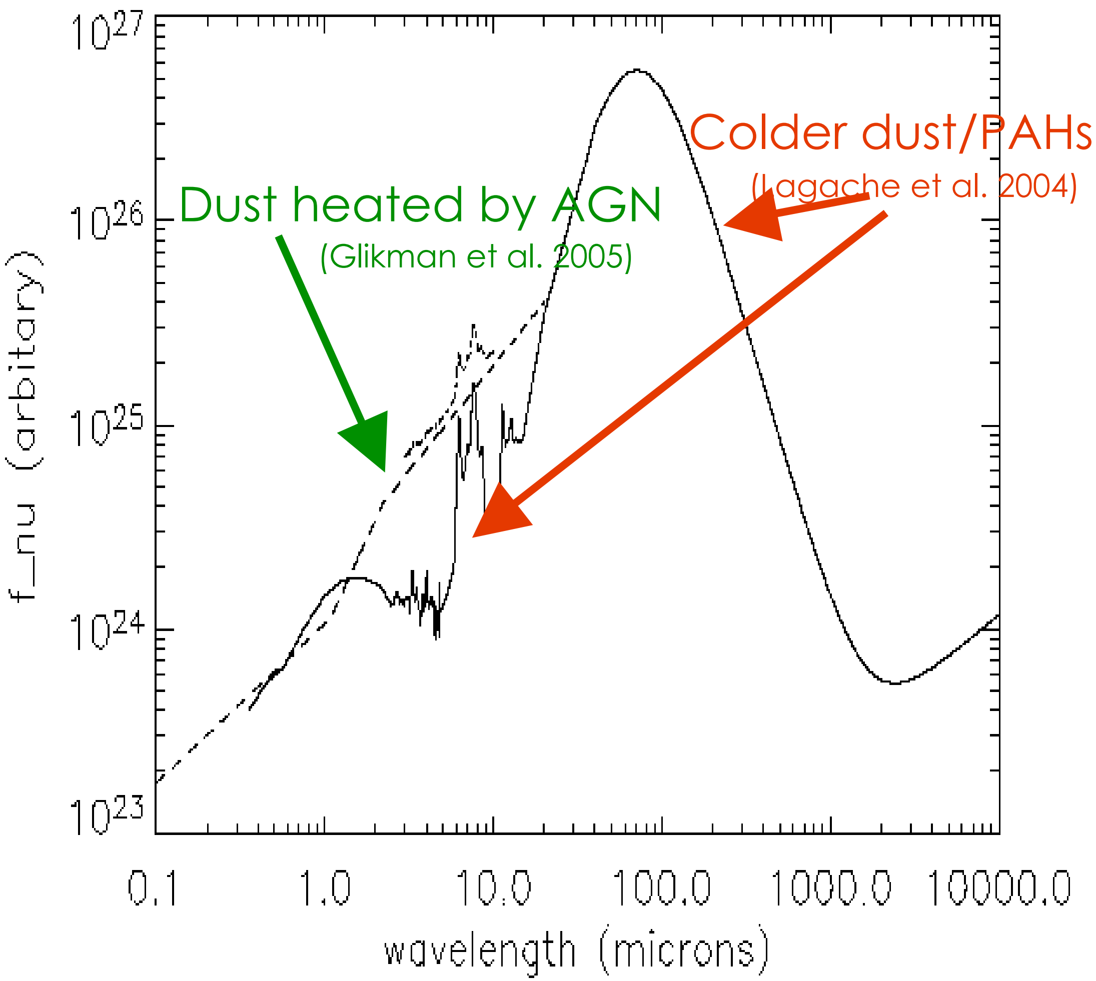


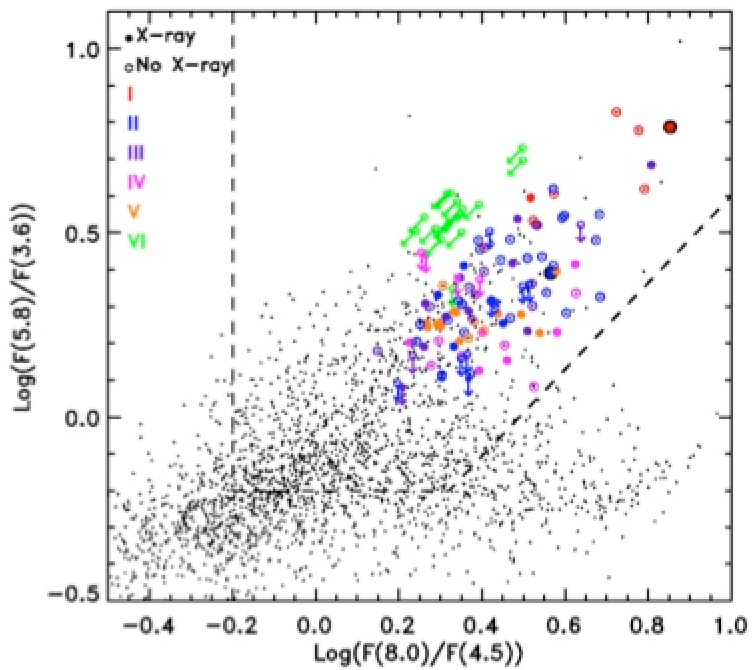
Open circles=logNH>23 (Tozzi et al. 2003)

Open squares = MIR/O>1000 sources

IR surveys

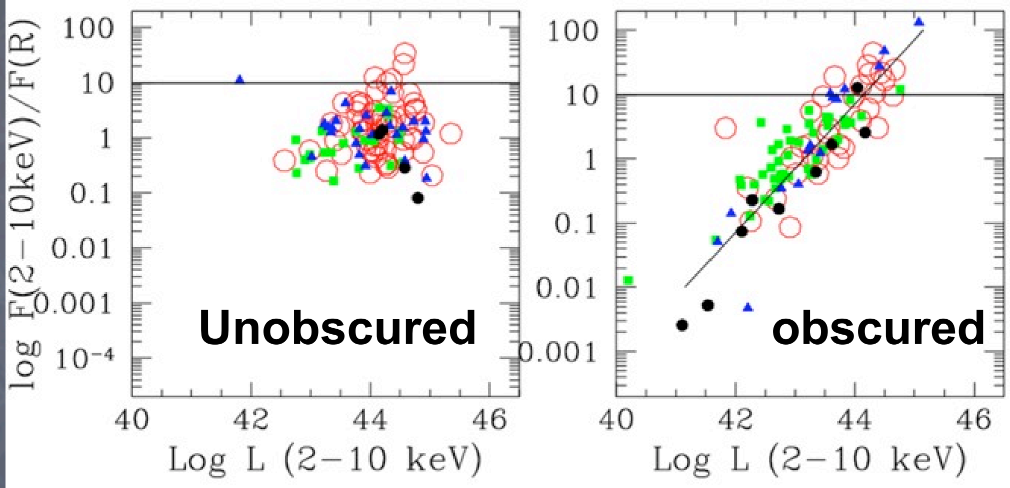
- Difficult to isolate AGN from star-forming galaxies (Lacy 2004, Barnby 2005, Stern 2005, Polletta 2006 and many others)



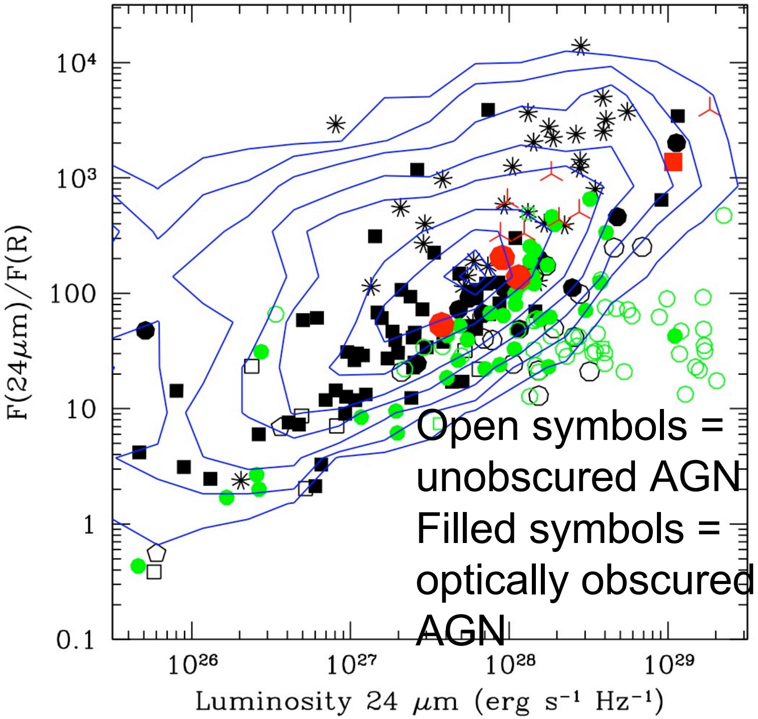


MIR selection of CT AGN

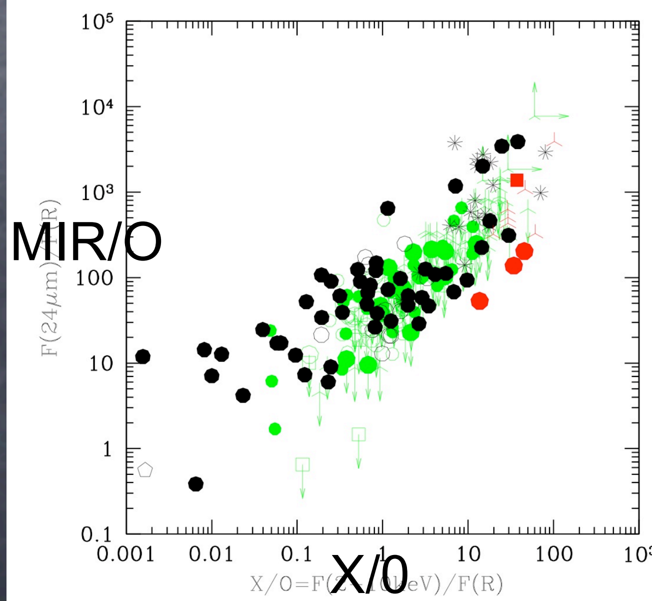
Fiore et al. 2003



ELAIS-S1 obs. AGN
ELAIS-S1 24mm galaxies
HELLAS2XMM
CDFS obs. AGN

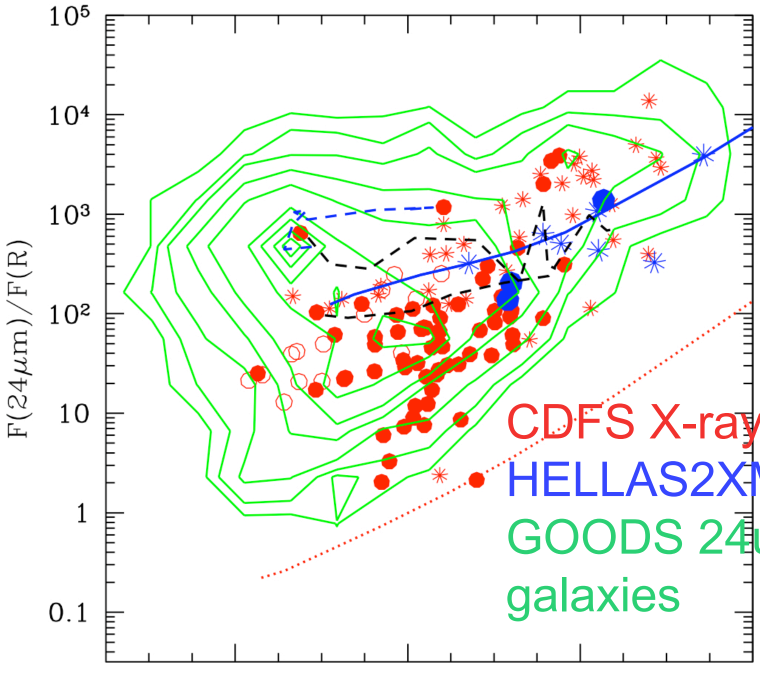


Open symbols = unobscured AGN
Filled symbols = optically obscured AGN



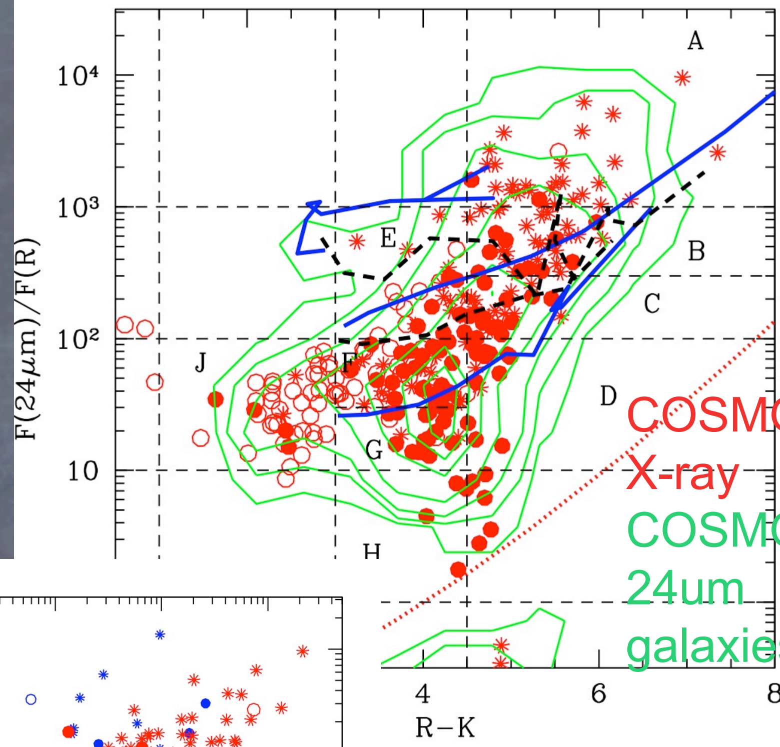
MIR selection of CT AGN

Fiore et al. 2008a

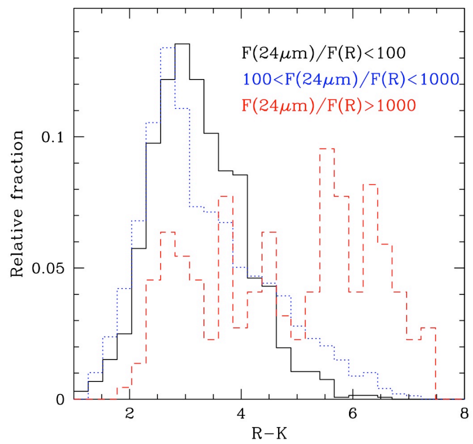


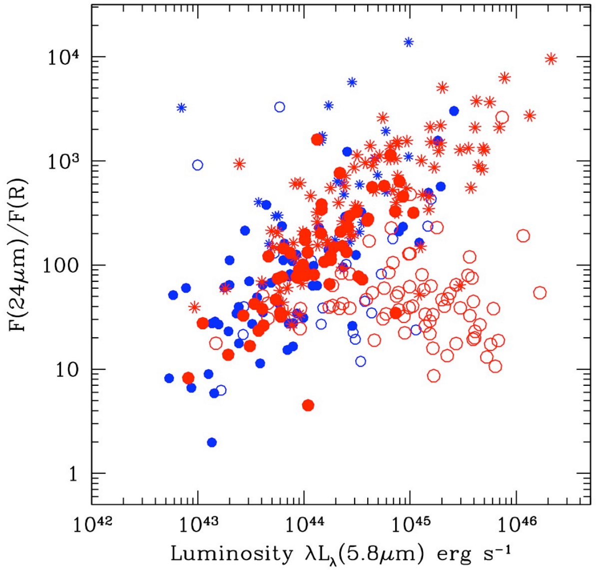
CDFS X-ray
HELLAS2XMM
GOODS 24um galaxies

Fiore et al. 2008b



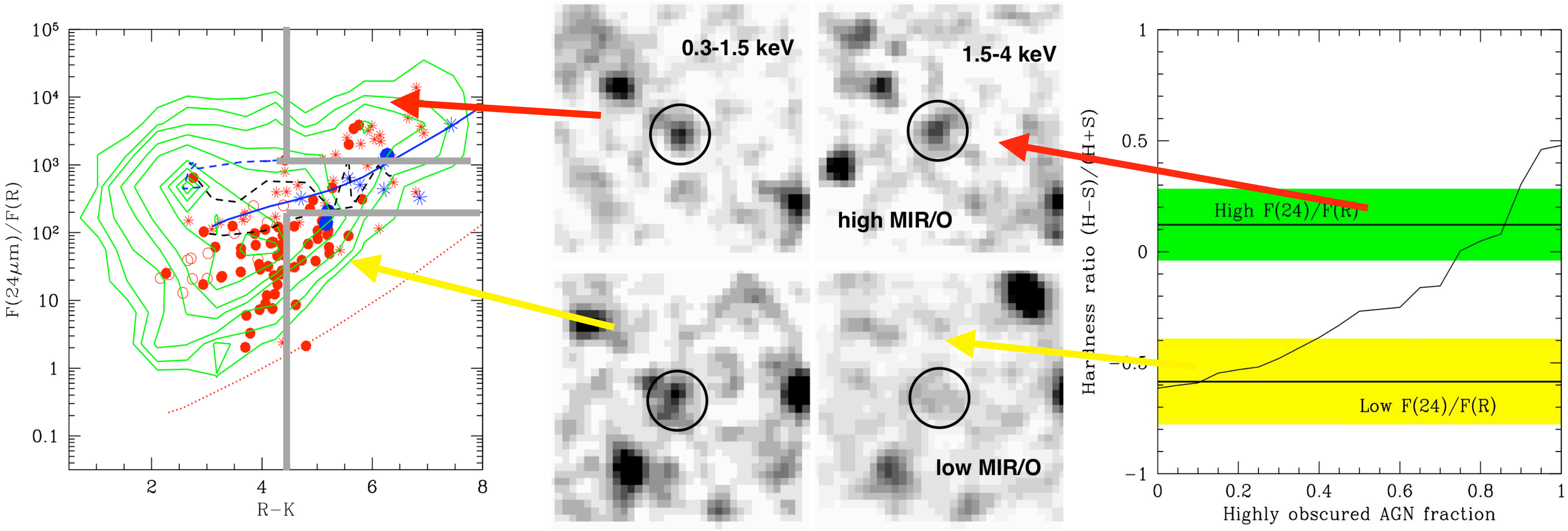
COSMOS X-ray
COSMOS 24um galaxies





Open symbols = unobscured AGN
Filled symbols = optically obscured AGN
* = photo-z

GOODS MIR AGNs



Stack of Chandra images of MIR sources not **directly** detected in X-rays

Fiore et. al. 2008a

- F24um/FR>1000 R-K>4.5
- logF(1.5-4keV) stacked sources=-17 @z~2 logL_{obs}(2-8keV) stacked sources ~41.8
- log<LIR>~44.8 ==> logL(2-8keV) unabs.~43
- Difference implies logN_H~24

F24/FR>1000 R-K>4.5

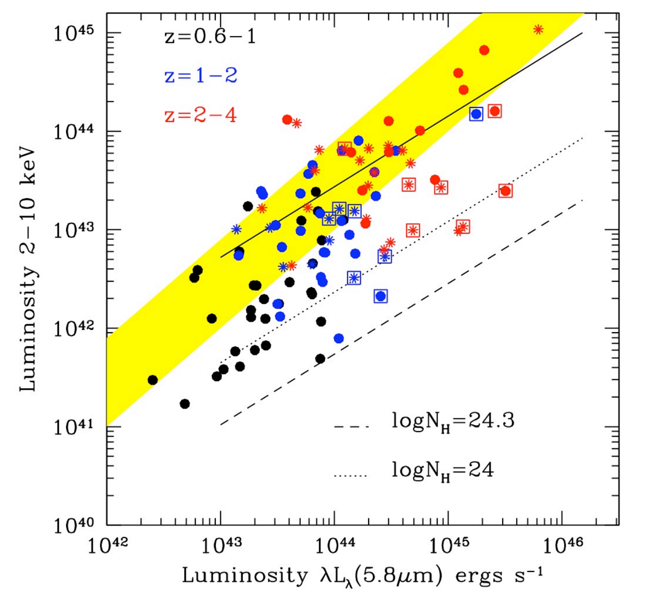
- <SFR-IR>~200!! Msun/yr
- <SFR-UV>~7!! Msun/yr
- <SFR-X>~65 Msun/yr

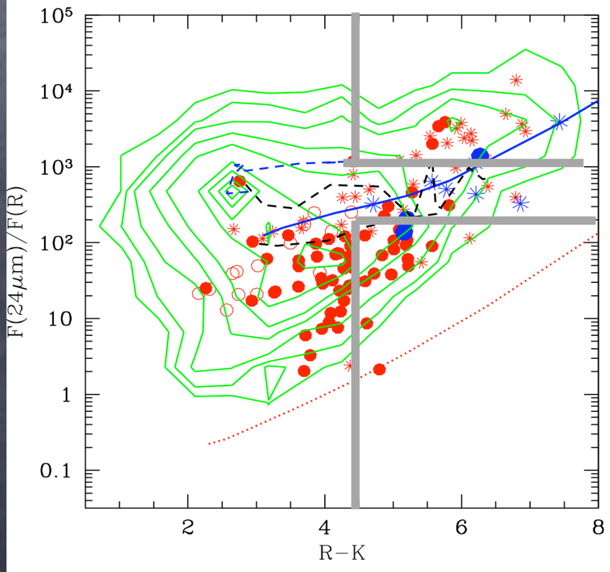
F24um/FR<200 R-K>4.5

- <SFR-IR> ~ 18 Msun/yr
- <SFR-UV> ~13 Msun/yr
- <SFR-X>~20 Msun/yr

Program of the project (1)

- Selection of IR sources with X-ray detection which are likely to host a highly obscured AGN
- Extraction of the Chandra spectra of these sources from the event files
- Characterization of the X-ray spectra: estimate of the absorbing column density
- Evaluation of systematic errors:
  - Background evaluation
  - Combination of data from different observations





Program of project (2)

- Selection of IR sources without a direct X-ray detection which are likely to host a highly obscured AGN
- 'Stacking' of X-ray images at the position of these sources
- Analysis of the 'stacked' images